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PROCEEDINGS

OF

The American Microscopical Society.

SIXTEENTH ANNUAL MEETING.

ADDRESS OF THE PRESIDENT:

A PLEA FOR SYSTEMATIC INSTRUCTION IN THE TECHNIQUE OF THE MICROSCOPE AT THE UNIVERSITY.

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I propose to offer some reasons why the technique of the microscope and its accessories should be systematically taught in our universities. By this I mean something more than the incidental instruction which is necessarily connected with the laboratory use of the instrument. A student always learns something by noticing the methods of his instructor, even if he is left to his own observation; but the competent teacher does more than set an example. He gives some elementary training in the use of all the apparatus of the laboratory, the microscope included. This, however, is what I have referred to as incidental. It is usually no more than is necessary to enable the student to begin his work of investigation without damaging the costly instruments by his awkwardness or making his observations valueless for lack of the simpler rules of manipulation. I wish to urge the desirability of a somewhat extensive course of technical instruction and training in regard to the microscope, backed by so ample a collection of stands, of objectives, and of accessory apparatus as shall give the university student the opportunity to judge for himself, under the guidance of a competent instructor, of the practical value for general or for special use of the various forms of instruments of different types. Any one who desires to devote himself seriously to investigation with the microscope would find great advantage, as it seems to me, in devoting some time to the study of the instrument itself in all its parts and the history of their development. He can hardly hope to do much in the way of personal experimentation with the instrument at his own cost, for few indeed are the men of science who can afford to make a collection of microscopes or of objectives (to say nothing of other accessories) for the sake of testing their excellences and of selecting and rejecting until they are sure that they are equipped with the best for their purposes. A fortune might be spent in this search, and the costliness of it makes it peculiarly the field of work for a great university, which may stock its cabinets with specimens of the best products of all nations and the brightest inventions of the most brilliant practical geniuses, and place in charge of them teachers of a spirit sufficiently catholic to appreciate the merits of all, and to show to the pupil each instrument under conditions which will thoroughly test its worth.

I do not advocate this as if such technical education could be substituted profitably for some part of the ordinary curriculum of scientific study. I think many advocates of technical schools have gone too far in arguing that training of the hands is also training of the mind. There is a sense in which it is true, but I am a firm believer that the scholastic education should be discriminated from the manual or the technical. We want both, but we do not want to confuse them. They do not supply each other's places, though the technical may be a most valuable supplement to the strictly intellectual training. I assume that the full or nearly the full amount of strictly intellectual work may be done, and to this may be added a reasonable course of technical work without causing overexhaustion or a sense of undue strain on either physical or mental powers. The latter becomes a sort of recreation after the former and will, within moderate limits, take the place of play. Not altogether, for active exhilarating amusement is necessary to wholesome human development; but for the quieter kinds of change which refresh mind and body. manual and technical instruction has its place.

It is in this practical way, as a collateral field of work which need not trench upon the scientific studies of the university, that I plead for a place for systematic instruction in the microscope and the numerous pieces of apparatus which are subsidiary or accessory to it, or which are directly concerned in preparing objects for investigation or in mounting them for permanent study and reference.

There has always been a disposition among a certain class of serious workers in science to question the *raison d'être* of microscopical societies; yet these have survived and have continued to be attractive to many of the most devoted scientific investigators in special and absorbing lines of work. The survival itself argues strongly that such organizations must have a sufficient reason for their existence; but as we run over the many points of interest in microscopical technique and note the numerous directions in which improvement has been made or asserted, the long list of accessories devised to assist in observation and which exhibit wonderful ingenuity, the great number of mooted questions in regard to construction, to excellence, and to usefulness, I think it becomes very plain that it is a large field, running-over full of most interesting questions for experiment and discussion—questions which deeply interest every one who tries to make scientific use of this wonderful means of investigation, and which naturally bring together all such workers because the technical and practical problems are the same, though their special fields of study in nature are different.

I urge the systematic handling of these interesting questions in a university course, because they are really important, because they are numerous, because they may be classified so that their elucidation may be a proper field for progressive instruction, and because the help which practical experience lends to their solution comes most unexpectedly from all the different departments of investigation in which the microscope is used. There is thus, in fact, a common ground on which all progressive students skilled in the use of the instrument should meet. There is an undeniable field for instruction in the technique of the instrument and its accessories. There is room for further improvement in the microscope itself and everything connected with it. There is need for a place where the worker may find everything of value which has been invented or devised, and an opportunity to learn or to test its value by actual comparison in use. If our universities will furnish the plant and the instructors, they will do, in a better and more thorough way, what the microscopical societies of Europe and America have been trying to do, or perhaps will make only more satisfactorily clear the advantage to science of such societies, by giving to every student the ground-work which will insure not only his progress but his lasting interest in these technical studies.

At each of the great expositions which have been held in the last half century there have been exhibits of microscopes and microscopical apparatus from the workshops of all the nations which lead the progress of the world's enlightenment. Their workmen of highest skill have vied with each other in carrying out the practical ideas of the most expert investigators and the profoundest theorists. Under this stimulus workshops have become scientific laboratories of great excellence, and what was once humble mechanical labor is now intelligent coöperation with the most refined scientific thought and invention. The great *atelier* at Jena, where scientists of such high and established reputation as Abbe and Zeiss, Czapski and Schott have been called from professors' and instructors' chairs to take personal charge of the several departments of microscopical manufacture and to devote acknowledged scientific eminence to the construction and improvement of our apparatus, is a wonderful object-lesson in the dignity and the elevation of the mechanic arts in close association with science. It is not too much to say that the extraordinary opportunities for comparison in mass which the expositions have afforded has had much to do with making such progress possible. The verdicts of juries upon the competitive exhibits have been of little importance compared with the stimulus exerted upon crowds of scientific and intelligent visitors from all parts of the world, who have unwonted opportunity to compare what is being done in different countries, and to form adequate ideas of the wonderful aggregate of invention, of thought, and of skill which has gradually accumulated a wealth of valuable aids to investigation and to the progress of knowledge.

But if the gathering of such exhibits at rare intervals and in distant places has such recognized value, what might we not hope for if they were permanent at the centers of learning, open not merely to inspection but to continuous use, under the control of expert teachers of manipulation who should make a profession of leading the student in investigation most rapidly onward to fullest knowledge of all the auxiliaries of his work, to soundest judgment of their relative value, and to expertest skill in their use? This is what I plead for, and that I may not seem to overestimate the desirability of such systematized instruction I shall ask your attention to a brief analysis of the lines of work open to the microscopical student, and of the questions in technique or in construction which may fairly be said to be still undecided. The substance of this will be very familiar to you all. All that can warrant my statement of it will be the attempt, by classification, to show that there is abundant room for a course of lectures of scientific character and of practical value and for laboratory work of no little amount and of real importance to the student.

Let us first consider the microscope itself from the point of view of the novice seeking to become master of it. He finds his interest aroused in three directions, viz., as to the lenses, the stand, and the accessories. In each of these directions he is confronted with problems which he would be glad to solve intelligently. He finds a long series of objectives running from one of three or four inches focus up to the seventy-fifth of an inch. There are more than twenty of them. What is the use of each, how many of them must he have, how many can he dispense with? But he also finds that each of these objectives is made with examples varying in the angular aperture. He must study the theory of the aperture, and should acquire clearly defined ideas of the difference between a wider and a narrower angled glass of the same focal distance. Theory alone will not serve him here. He needs a competent instructor to show him by experiment the difference in performance between them, the purposes for which each is adapted, and the manner in which the aperture limits the power. He begins with supposing that if one glass magnifies a hundred diameters and another three hundred, this is the only increase of power that he need attend to. He is naturally surprised to find that for the discrimination of the minute details of objects the mere increase of size is of minor consequence; it is the angle of aperture that counts. It is not enough to know this theoretically. It is only realized and made profitable in investigation when it has been made practically familiar by experiment with numerous good specimens of lenses, repeated again and again until it has become part of the mental property of the investigator that will habitually control his work without his stopping to think about it. He can't afford to learn this by the costly method of buying all the different glasses. His opportunity of comparison by the courtesy of friends may be small, however willing investigators may be to help each other, for the outfit of each may be small, or his work may keep him more or less isolated so that a brother investigator is not at his elbow. It is part of the elementary and practical instruction which, if given at the university as fully as it may be, will make the microscopist sure of his judgment and save him trouble and doubt and money as long as he lives.

I have often seen the expression of lively surprise with which the student first realizes that a glass with a magnifying power of three hundred diameters may be made to show him details in natural objects which are too fine for another lens with a power of five hundred diameters. He is almost sure to jump to the conclusion that the first is a much more perfectly finished instrument than the other; the one a good glass, the other a bad one; the last a *cheap* glass, the first properly a costly one. Here he has to be corrected again, and must learn that this is not true in the sense he first gives it. Each may be an equally perfect instrument of its class. As much labor and skill may have been bestowed upon the one as upon the other. The spherical corrections and the chromatic corrections may be equally complete in both. Each may be rightly judged worth the price it costs, and may be equally a credit to the optician who made it. It is no question of better or worse, of being worth more or worth less. The glasses are only constructed upon different formulæ, with predetermined difference of results. The outcome of this lesson is that the tyro learns that he must select his tools, even his lenses, according to the work to be required of them.

But there is a question of better or worse, of good and bad, is there not? Certainly, but this must be determined by a comparison of results when the lenses are of similar aperture and are used in work to which they may properly be put. There are such things as good and bad definition, flatness or curvature of field, images of pure color, and others fringed with prismatic tints. In short, there are well made, well finished and corrected lenses, and those that are not, and the discrimination of these may be taught, so that a poor glass, if wider angled, cannot be palmed off for a glass of better finish and construction. To learn it the student must be made practically familiar with acknowledged standards in all the different classes, and this can only be done through long years of tentative effort, in the midst of doubt and uncertainty, and at a waste of money and means that a scientist should be spared, unless he is helped by the systematic instruction and the opportunity for large comparison and experiment which only the university can be expected to offer him.

Other questions that will arise relate to the proper uses for dry and immersion glasses, and among immersion lenses the relative uses of water and of the homogeneous systems. These questions are again intimately connected with those of aperture, and lead on to an appreciation of the latest improvement in microscopes, the apochromatic objectives. Here also it will be found that various uses are best subserved by the tools specially adapted to them, and that it would be a mere waste of costly apparatus to apply the most delicate instrument to work within the range of a lower power or a narrower angle. This is illustrated in the use of objectives with collar correction for cover. It is a reproach to many who work a good deal with the microscope that they have never become expert in the use of this correction. The nicer adjustments are wholly beyond their skill, and they work along, often for years, with a complete ignorance of what their own lenses are capable of. Their steps are far less firm, even in their own specialties, than they would be if good elementary education in the use of their instrument had made them capable of putting it through its best paces. A competent instructor in a single hour over Möller's test plate will give a young microscopist such ocular demonstration of the difference between good and bad handling of the same glass that the remembrance of it will haunt him, as Themistocles was haunted by the trophies of Miltiades and spurred on to a noble emulation. It is often asserted that when we shall use only the apochromatic homogeneous immersion lenses no adjustment for cover will be necessary. Even if this be true theoretically, there are considerations which make it practically untrue: First, that we are rarely sure that the so-called homogeneous immersion is truly such. The refractive index may be changed by evaporation or by absorption of moisture or by accidental dilution. If so, the homogeneity is only approximate and the use of the adjustment collar is a necessity. Again, if we are not sure of the quality of the immersion medium, and have not the opportunity or time to test the refractive index, the accustomed use of the collar correction soon helps us remove the doubt which would otherwise follow us through our nicest observations. If the medium is right, it helps us prove it. If it is not right, it helps us correct it. Finally, we may often wish to use a glass when only glycerine or water is at hand as an immersion, and in this case the power of adjustment by the collar is absolutely necessary for tolerable work. My own experience has induced the belief that no homogeneous immersion glasses have yet been made in which the performance is with light of extreme obliquity absolutely the same as with central light, some closing of the systems being desirable as the obliquity of the light increases. Complete equality of refraction in the slip on which the object is mounted, the medium in which it is mounted, the cover glass, and the immersion fluid is in practice not attained, and the need of the collar adjustment therefore remains. Van Heurck, in the last edition of his work on the microscope, recognizes this in photomicrography, where his authority is second to none. But the very fact that there is here debatable ground is enough for my present purpose, which is to show that such debates can be most certainly and satisfactorily settled by the systematic use of means and of instruction which only the university can give to the multitude of scientific students.

The use of the eye-pieces opens another series of problems of considerable interest. The combination of the lenses at the two ends of the tube to make the compound instrument was one of the great strides of microscopical progress, and like all combinations it involved the possibility of permutations of the parts and their relation to each other. How far apart shall ocular and objective be set? How large shall the field lens be? What is the relative value of the various forms of oculars—the Huyghenian, the Kellner, the Ramsden, the projection, etc.? Is a large optical field desirable generally or only for special purposes? Are there advantages in using a contracted field? It will at once be seen that here are questions in regard to which the real student will not be content to follow some popular hand-book or even the *ex-cathedra* opinion of a teacher; he wants to fix his basis of judgment by actual experiment, repeated till he is sure that he knows whereof he affirms The technical laboratory of the microscope abundantly supplied with good instruments is needed to give him this opportunity to acquire knowledge as distinguished from mere *dicta*. But we are not yet through with the oculars They may be combined into binoculars by the Wenham prism, or into the binocular eye-piece of Abbe, or into the orthoscopic arrangement of Riddle, of Stevenson, or of Nachet. Over all these lively debates have been waged, some declaring them all mere toys, and others equally expert insisting that the binocular microscope has the same advantages in use that the binocular field-glass has on the deck of a ship, in the hands of a reconnoitering army officer, or in the stalls at the opera. The discussion has often been a mere collision of counter-assertions or counter-prejudices. It is not always so amusingly absurd as it was once in the case of a friend of mine who, after hotly insisting that the binocular is worse than useless, wound up by naïvely confessing that his own eyes were of unequal focus, which was of course a natural and conclusive reason why the binocular was useless to him! We do not want opinion on such subjects; we want experiment—the appeal to the actual use with the leisure and under the circumstances which will favor solid conclusions for ourselves. The theoretic limits of your apparatus must also be kept in view. A gentleman of considerable experience in the use of the microscope once gravely informed me that the Wenham prism made by a well-known optician was the only one which gave a well-lighted field with a high-power objective. He adjusted his instrument and there was a lighted field, it is true, but lo! on closing the right eye the field of the other was so totally obscured that its darkness had prevented even the sense of interference. In all such directions systematic instruction with comparative use of instruments would give certainty and definiteness of knowledge.

The stand of the microscope is only the metal frame which supports the lenses and the accessories and which gives a convenient means of supporting the object to be examined and of bringing its various parts into view; but a convenient and nicely adjusted arrangement of all these parts is essential to the successful use of even the best of lenses. Whenever complicated uses are demanded our mechanical contrivances become a "machine," which should be so devised as to be most easy and reliable in its adaptation to every purpose. The different parts should be so placed as not only to be most easy and certain in manipulation, but so that the hand may pass from one to another with greatest facility and with least awkwardness or loss of motion. In an instrument which magnifies the visual appearance of objects the effect of every improper motion or vibration is also magnified, and solidity with exactness of mechanical construction and finish become of great practical importance. These conditions have made of the microscope a machine of considerable complexity, if it be adapted to the finer and more delicate work. They have brought into discussion every part of it and induced the most curious varieties of form for every part. A comparative study of these variations is useful and interesting. They are found in all the four principal divisions of the instrument as a whole, viz., the tube, the stage, the substage, and the base.

Following my plan of only indicating the classification of the things worthy of such study as I am recommending, I begin with the tube. I have already hinted at the question of the diameter of the tube in speaking of the oculars. I may add that in use for photography there is an advantage in having the tube of the instrument large enough to give room for considerable divergence of the rays of light from the back of the objective, so that the illuminated field on the photographic negative may not be unnecessarily diminished. In an instrument designed for general use this is worthy of consideration, and much experiment may be made in determining the limits in this direction; but the motion of the tube in focusing is that which has attracted most attention. Every instrument above the most rudimental has what we call the coarse and the fine adjustment for focus. The common aim is to make both of these reliable, steady, and smooth. The devices to secure this are numerous. Many of them are exceedingly ingenious. No diagrams can enable us to say with certainty which will work best in practice. The actual comparison in use is again found to be necessary, and this not once or twice, but often enough and long enough to lead to satisfied conviction. The fine adjustment, in order to work well with highest powers, must give micrometric motion with perfect evenness, with no loss of motion when changing direction, no "back-lash" when the hand is removed from the screw. To secure this a great number of ingenious plans have been devised. We have a screw working against a spiral spring which carries the whole body of the instrument. We have a lever working against a spiral spring which carries the nose-piece, and this lever may be several inches long, working in the whole length of a transverse arm, or it may be quite short and work only within the diameter of the tube. The long lever may carry the whole body and work against a spiral spring. Then there is a plan for direct motion by means of a differential screw; another with a combination of screw and wedge; still another with a screw working against a pair of straight steel springs which carry the body of the instrument.

The variety of these devices proves that there has been felt a real need for improvement, and that in most delicate work the matter is found to be one of importance; yet a number of these devices are patented and can only be had in connection with instruments manufactured by the patentees. If full study of them should lead to a general conviction that some one or two were decidedly superior to all others, the opinion of microscopists would no doubt lead to the sale of the right to use the chosen device upon various forms of stand, and so bring it within reach of all; but as long as the use of it is restricted to a form of stand that may not be generally liked the merit of the device will not be commonly recognized. The university which distinctly aims to have every promising improvement represented in its cabinets, and to give the most thorough opportunity for comparing it with others and testing it, may in this way do what private investigators cannot afford to do, and progress in our apparatus may be made at once certain and rapid.

The same considerations apply to the so-called substage accessories. The illumination of the object is scarcely less important than the lens by which we view it, and in no part of our technique has change gone on faster. Condensers, both chromatic and achromatic, spot-lenses and paraboloids, hemispheres and disks, and immersion prisms, have all been used, not as mere toys and fads, which have their day, but with a constant progression toward more complete methods of securing results which are valuable beyond dispute. The comprehension of the uses of oblique light and the philosophy of its relation to the phenomena of diffraction has been among the more recent of the triumphs of physical optics. A course of study in it, illustrated by experiment showing the uses of the apparatus to which I have referred, could not fail to be of deep interest to the student and of permanent benefit. If the result should be to make him better satisfied with the simple outfit which the slender purse of the young investigator commonly confines him to, this will be in itself a positive and lasting gain. He will not, in that case, be tortured with the fear that he is losing the best results of his work for lack of instruments which he cannot afford; but if his investigations may be made more fruitful by instruments specially adapted to his needs, he will be able to select these upon sound principles, and not go on impoverishing himself, as many do, in purchasing what is boldly advertised or rashly recommended till he reaches satisfactory results by the costly path of his own experience. His *alma mater* might save him from this.

The stage of the microscope is itself an interesting piece of mechanism in its completer forms. The primitive form of a plain brass plate with a hole in it is still all that is really needed for a great deal of the microscopist's work; but he has fields of investigation where he needs mechanical help beyond this. For some uses he wants to revolve the stage, with the object attached, so as to illumine it from every azimuth in turn. In petrology the angular extent of the revolution should be shown by an accurate scale. For this and some other purposes it is well to have means of centering the stage with the optical axis of the tube of the microscope. For accurate micrometry the stage needs good rectangular motions. For noting the place of an object on a slide so that it can be found again, there must either be scales and verniers upon the stage itself or it must be supplied with stops, so that the Maltwood finder may be conveniently used. It must be shaped so that light of the utmost obliquity may readily reach the object. To secure each of these results laborious ingenuity has been at work and a multiplicity of forms has resulted. Again, the student is bewildered with the many devices offered him, and can rarely get any reliable help in determining what he shall choose and what he may omit or postpone. The scientific solution would be an instrument on which the various improvements may fit as additions to a properly constructed foundation, and which may be added as the needs of one's work may demand and the depth of one's pocket may permit. It ought not to be necessary to throw away one instrument to purchase a complete and more elaborate one; but here the interests of trade are not quite in harmony with the interests of the student, or perhaps it would be fairer to say that the demand of the purchaser is not so intelligent as to have called out the proper supply. If each investigator had taken a really good course in technique and had established principles of judgment in regard to his own needs, the tendency to harmony of opinion, and consequently of demand, would be so strong that we could reasonably expect the enterprising manufacturers to come more than half way to meet it.

There still remains the subject of the microscope *stand*, in regard to which there has been much debate and no little prejudice. The stand is merely the mechanical support for the lenses, the object, and the accessory apparatus; yet it must be well adapted to its work or investigation becomes most tedious and unsatisfactory. The essential quality of a good stand is a design which will carry all of the other apparatus in such a way as to be most convenient for its practical use, which includes its easy and rapid change and interchange. The only beauty we may properly demand of it is the beauty of manifest and thorough utility. Everybody who is at all familiar with mechanism knows that there is a beauty of proportion and design which is recognized when the arrangement of parts indicates a unity of idea and purpose which marks a good original plan. We often see instruments which were plainly designed without reference to any of the modern improvements which have almost revolutionized their use. These improvements are attached, but in a sort of hap-hazard way, and are often carried by the parts of the stand which, on every true principle of construction, should be free from such weight and encumbrance.

The "substage," as it is seen in most English and American microscopes, is made to move upon a part of the solid body of the stand in such a way that it can be entirely removed in an instant. It is itself so formed that the various pieces of illuminating apparatus are interchangeable and easily centered. I do not see how it can be doubted that this construction is a good one, mechanically, and one that may fairly be considered essential to a good modern instrument. It is sometimes objected that it requires so much space below the stage as to make the scale of the whole instrument of too great size and weight. It is upon precisely such questions as these that full opportunity of comparative use, under intelligent guidance and teaching, seems to me most promising of good results. The question of size is a relative one. Portability is a merit in any mechanism, but no one thinks of complaining that he cannot carry an astronomical telescope in his microscope case. We need to put large and small microscopes side by side, and, with patience and labor enough to master the use of each, determine upon sufficient experiment the relative advantages of all. Those who have said that the largest English instruments cannot be conveniently used in an upright position may learn a useful lesson by looking at Dr. Dallinger's method of using his "Powell & Lealand" upright, as illustrated in the new edition of Carpenter. But the substage arrangement of accessories does not necessarily imply large size. If portability is important, the best mechanical form may be reduced in measurement. Joseph Zentmayer, in his lifetime, adapted one of his small histological stands for me to the complete use of a sliding substage carrying all the subsidiary apparatus used upon the largest, including a very complete polarizer with a full set of nicol prisms and changing selenites. The arrangement was a complete success in every way, and by sliding off the substage the instrument became at once as light and small as the simplest of the histological pattern.

How far is portability desirable? There is a size of parts and of screws and milled heads that fits the hand and allows room for manipulation with freedom and ease. There is also a relation of part to part, so that if you use the ten-inch tube the balance and stability of the whole instrument will call for a relative enlargement of the space below the stage and a broader spread of the base. Are these anything more than whims and habits with us, or is there a practical convenience which will assert itself on fair experimental comparison? I believe that rational and thorough study of this part of technique will produce a general harmony among microscopists, and that there will be a scientific evolution of the most useful forms and sizes. Only let natural selection have fair play and I cannot doubt that our instruments will rapidly become the best possible.

The imitative tendency of human nature is as noticeable among scientific men as elsewhere. We do this or that because it was done so in the laboratory of so and so, whom we worship. We use the instrument our teacher used without asking whether his success as a teacher was because he used it or in spite of his using it. I remember very well, and so do most of you, when students from certain great and deservedly popular schools in biology scouted all microtomes and argued that free-hand cutting was a better way of section-making than any mechanical one. Now the microtome is a complicated machine, and the most elaborate have been devised where once simplicity was a *cult*. The majority follow their leaders now as then. The remedy for this is the opportunity for proving all things by the systematic study of technique under favorable conditions. A fresh, bright mind in a laboratory, when encouraged to use his own ingenuity, is constantly surprising us by the fertility of his invention and the rapid progress he will make. Give him the same opportunity in comparing the merits of his instruments and apparatus; supply him with good examples of all the different styles and kinds; free him from bondage to any tradition and stimulate him to use his own powers here as you do in pure science, and I cannot doubt he will surprise us, not only with the justice of his choice, but with still greater improvement in all that makes investigation with the microscope sure and easy.

In the department of microscopical accessories the list is so large that, in despair of being able to treat it properly, I must pass it by with the general remark that in this direction the temptation is great to expend money that the student cannot spare, and that the opportunity to prove all things in order to hold fast that which is good will be a boon to him. In every field of work there are devices so useful that one can ill afford to be without them, and yet, prior to actual experience in their use, there is risk of costly blunders in making the selection. Treatises on the microscope are not enough for us. No one can appreciate more fully than I do the value of the writings of Carpenter, Beale, Dallinger, and Van Heurck, but we must remember that it is the office of the treatise to furnish fullness of catalogue with only general criticism of the relative usefulness or necessity of each contrivance. The question of cost it must ignore, or it becomes little more than a trade catalogue. Whether a piece of apparatus is worth the money it costs is a question the answer to which depends so greatly on the ability to buy, that we constantly find ourselves in need of advice directed to our special situation and work. It is not enough to be told that the device accomplishes its purpose; we want to know whether the same result can be secured by simpler or less costly means. We need the personal assistance of a disinterested friend and instructor and the practical teaching of actual experience. How can these be given so well as in a laboratory devoted to the technical education for which I am pleading, fully supplied with the instruments to be tested?

From whatever point of view we approach the subject, it seems to me that all sound reasoning and practical experience agree in sustaining my proposition that systematic and thorough training in the use of the microscope is highly desirable, and that the university is the school to which we naturally look for the means to meet the want. In arguing this before the American Microscopical Society I may be justly criticised for "carrying coals to Newcastle," but I hope that my words may be heard beyond the borders of our own organization, or that at least you will be stimulated to become the active propagandists of a doctrine in regard to which we are of one mind. Every one of our meetings gives new evidence of the zest with which earnest investigators seek new light upon their methods and compare their experiences with those of their friends. We bring the problems which the year has developed, and we bring our solution of them or the tale of our difficulties in seeking it; we examine with keenest interest the new devices which skillful opticians offer as helps in our work. Our working session is a specially fruitful field, in which deftness of manipulation is exhibited, aided by both general and special devices. I am only urging that what we find so necessary a part of our continuous education that we look forward through the whole year to this exchange of ideas and of practical knowledge, may be given an assured place in university work and be at least solidly and thoroughly based upon a course of technical instruction which shall save the young investigator from much of the doubt, the error, and the cost through which we ourselves have had to make our way. Is not such a result desirable, and does it not open what we may fairly claim is a field for real improvement in liberal education ?